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OBJECTIONS

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MR. REDFIELD'S THEORY OF STORMS,

WITH SOME STRICTURES UPON HIS REASONING.

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OBJECTIONS, &c.

1. MR. REDFIELD'S idea, that tornadoes and hurricanes are all whirlwinds, involves some improbabilities. It requires that, during every hurricane, there should be blasts of a like degree of strength coinciding with every tangent which can be applied to a circle. Thirty two ships equidistant from the axis of gyration, and from each other, should each have the wind from a different point of the compass with nearly equal force. The only modification of which this view of the case admits, is that resulting from the progressive motion which tends to accelerate the wind on the side on which this motion concurs with that of the whirl, and to retard it upon the other side. Moreover, as respects any one station, the chances would be extremely unfavorable that the same hurricane should twice proceed from the same quarter! Yet in the course of time it would be felt, at any station, to proceed from many different directions, if not from every point of the compass.

2. The fact that during the same storm different vessels variously situated are found to have the wind in as many different directions, may be explained by the afflux of winds from all quarters to a common focal area, as well as by supposing them to be involved in a great whirlwind. Mr. Redfield has alleged that he observed proofs of gyration in the effects of the New Brunswick tornado; but I think that the survey of Bache and Espy, shows that it would be inconsistent with the facts to suppose such a motion, unless as a *contingent* result, and that it could only be a casual effect of the currents rushing towards the axis of the tornado.

3. Being of opinion that calorific expansion is inadequate to explain the afflux of wind towards the equator, the same author alleges that "*the space previously occupied by the atmosphere, so left behind is by the centrifugal action of the earth's rotation, constantly supplied from higher latitudes.*"

4. I presume that the meaning of this allegation is, that the centrifugal force communicated to the air at the equator by the diurnal revolution of the earth, lessening the gravity of the air thus

affected, causes it to rise and give place to those portions of the atmosphere, which existing where the diameter of the earth is less, have less rotary motion. Admitting an afflux to arise in this way, could it have any other effect than that of accumulating air over the equator, compensating by quantity and altitude for the loss of weight arising from a greater centrifugal force pertaining to that region? But on the other hand, if we attribute the ascent of the air at the equator to heat, the theory of calorific circulation will account for the continuance of the process.

5. In ascribing the prevalence of westerly winds in the upper regions of the atmosphere to the deflection of the trade winds by our mountains, Mr. Redfield's explanation harmonizes with the theory of Halley. In fact as the water accumulated by these winds, in the Gulf of Mexico, is productive of the Gulf Stream, is it not reasonable that there should be an aerial accumulation and current, corresponding with that of the aqueous current which is designated by the name above mentioned? But not perceiving that the trade winds cannot be explained without the agency of temperature, Mr. Redfield, in the following paragraph, rejects the influence of heat.

6. *"To me it appears that the causes of the great storms may be considered to indicate with entire certainty the great law of circulation in our atmosphere, and that the long cherished theory, which is founded on calorific rarefaction, must give place to a more natural system of winds and storms, founded mainly upon more simple conditions of the great laws of gravitation."*

7. It would seem from this paragraph, as well as others, that Mr. Redfield considers gravitation, uninfluenced by heat or electricity, mainly the cause of atmospheric currents. But in the absence of calorific and electrical reaction, what other effect could gravitation have unless that of producing a state of inert quiescence. The part which it performs in the mechanism of nature is well illustrated by that which it performs through the medium of a clock weight, which is of no use without being wound up.

8. It is remarkable that the author after ascribing the trade winds to momentum, as the antagonist of gravitation, loses sight of it in this summing up of the causes of atmospheric currents.

9. If, as Mr. Redfield alleges, the minuteness of the altitude of the atmosphere in comparison with its horizontal extent, be an objection to any available currents, being induced by calorific rarefac-

tion, wherefore should not momentum, or any other cause diminishing or counteracting the influence of his favorite agent, gravity, be on the same account equally inefficient?

10. Assuming that the motion of the air in hurricanes, is *always gyrotory*, Mr. Redfield considers *gyration* as a cause of these terrible meteors. How far his language on this subject is reasonable or consistent, may be seen from the following paragraph, which I quote from one of his essays. See this Journal for 1834, Vol. xxv, p. 125.

11. "*Notwithstanding these general and determinate horizontal movements, the equal distribution of the atmosphere over the surface of the globe, which results from gravitation, tends to prevent any very rapid or violent motion in any specific direction, and consequently to prevent violent and destructive winds. But owing to the tendency of all fluid matter to run into whirls or circuits, when subject to the influence of unequal or opposing forces, a rotative movement of unmeasured violence is sometimes produced. This peculiar movement, which in its most active state is sometimes distinguished by the name of tornado or hurricane, assumes every possible variety of position, appearance, velocity and extent, and is the only known cause of violent and destructive winds or tempests.*"

12. Agreeably to this paragraph, gravitation in lieu of being, as previously alleged, the *main basis of winds and storms*, tends to produce that equal distribution of the atmosphere over the surface of the globe on which I have insisted.

13. But if neither gravity, nor calorific expansion, nor electricity, be the cause of winds, by what are they produced?

14. He alleges that all fluid matter has a tendency to run into whirls or circuits, when subject to the influence of unequal or opposing forces; and that, in this way, a rotative movement of unmeasured violence is sometimes produced.

15. If this were true, evidently whirlpools or vortices of some kind, ought to be as frequent in the ocean, as agreeably to his observation, they are found to be in the atmosphere. The aqueous Gulf Stream, resulting from the impetus of the trade winds, ought to produce as many vortices in its course as the aerial currents derived from the same source; especially as in the ocean, the great laws of gravitation have full liberty to act, without any important interference from calorific changes, to which the advocates of the

agency of such changes in producing wind, will not ascribe much efficacy where non-elastic fluids are in question.

16. There are few vortices or whirlpools in the ocean, because there are in very few cases descending currents, to supply which the confluence of the surrounding water is requisite. Of course vertical currents cannot arise from any imaginable cause.

17. The conflict of opposing or unequal forces does not produce curvilinear motion unless there be a successive deflection; as in the case where it results from centripetal force, or the influence of gravity upon a projectile. If one of two opposite forces be less than the other, retardation will ensue, and a lateral current or currents, carrying off the excess of momentum. If currents encounter each other obliquely, a diagonal current will result. I doubt if a whirlpool ever takes place without a centripetal force resulting from a vacuity.

18. But the author has not informed us how these unequal or opposing forces are generated in the atmosphere. Without any assigned cause, he appeals to "*certain unequal or opposing forces by which a rotative movement of unmeasured violence is produced*;" this rotative movement, although alleged to be an effect in the first instance, is stated subsequently to be "the only known cause of violent and destructive winds or tempests."

19. In a memoir on the causes of tornadoes, and in some subsequent communications published in the Transactions of the American Philosophical Society, and republished in this Journal, various facts and arguments were mentioned tending to prove that the proximate cause of the phenomena of a tornado is an ascending current of air, and the afflux of wind from all points of the compass to supply the deficiency thus created.

20. In this mode of viewing the phenomena, no difference of opinion exists between Espy and myself, however we may differ respecting the cause of the diminution of atmospheric pressure within the track of a tornado, which gives rise to the ascending current.

21. I adduced several facts, upon the authority of the accurate survey made by that gentleman and his associate, proving that the effects were, in some cases, inconsistent with the existence of a whirl; and I mentioned one which could not be explained without attributing it to a gyratory force. Hence I was led to consider gyration as a casual, not an *essential feature* in the meteors in ques-

tion. It appeared reasonable to suppose that the conflict of confluent streams of air, rushing towards an axis moving progressively, might be productive of a whirling motion. The contortion of six feet of the upper part of a brick chimney upon the lower portion, so as to cause the corners of either portion to project beyond the sides of the others, was deemed inexplicable, without ascribing it to a gyratory force. Subsequently, however, it occurred to me that this fact was more likely to be the result of a *local* than of a general whirl; since, in the latter case, the chimney could not have been twisted as described without being precisely at the centre of the whirlwind. That such could have been its position, appeared to me to be extremely improbable, and had it been so situated, as the whirlwind was estimated to be moving progressively, at the rate of seventeen miles per hour, it is to me incomprehensible how the portion which was dislocated could have escaped an overthrow. Evidently, although twisted upon its base while concentric with the axis of gyration, it would in one second of time have been twenty feet upon the windward side of it, and consequently subject to the tangential force of the whirlwind. I adduce this, as well as other facts, to prove, that in tornadoes and hurricanes, there are local whirls, causing bodies, which are of a nature to favor an electrical discharge, to be particularly affected.

22. A fact, irreconcilable with a general whirling motion, has been recorded by Messrs. Espy and Bache. A frame building was so situated as to be protected by another edifice in one direction from the suction of the tornado, and yet was exposed to its influence as it advanced, and as it moved away. Hence two of the four posts, on which the frame rested, were so impelled by the wind as to make furrows in the ground, of which one was nearly at right angles to the other. Evidently such furrows could not rise from the transient tangential impulse of a whirlwind.

23. Mr. Redfield admits that the confused directions of fallen bodies is distinctly recognized by all the parties to this inquiry. Conceding, that amid this confusion, he has been enabled, by a survey, to show that the directions in which certain trees fell are consistent with their having been subjected to a whirlwind, it does not demonstrate gyration to be an essential feature of tornadoes. It is sufficiently accounted for by considering it as a fortuitous consequence of the conflux of currents rushing into a space partially exhausted.

24. Mr. Redfield adopts the singular determination of not noticing "the insuperable difficulties" of the hypothesis which he has undertaken to set aside. As the advocates of the disputed hypothesis are not aware of any such difficulties, is it correct to allege their existence, without mentioning the facts and arguments which justify this allegation?

25. Without repeating here the evidence and the reasoning which I have already published on this subject, I will advert to one fact which is utterly irreconcilable with Mr. Redfield's "rotary theory;" I allude to the statement of a most respectable witness, that while the tornado at Providence was crossing the river, the water which had risen up as if boiling within a circle of about three hundred feet, subsided as often as a flash of lightning took place. Now supposing the water to have risen by a deficit of pressure resulting from the centrifugal force of a whirl, how could an electrical discharge cause it to subside?

26. I have already, I trust, sufficiently shown that the explanation which Mr. Redfield dignifies with the title of his "theory of rotary storms," amounts to no more than this, that certain imaginary nondescript unequal and opposing forces produce atmospheric gyration, that these gyrations by their consequent centrifugal force, create about the axis of motion a deficit of pressure, and hence the awful and destructive violence displayed by tornadoes and hurricanes.

27. I cannot give to this alleged theory the smallest importance, while the unequal and opposing forces, on which it is built, exist only in the imagination of an author who disclaims the agency either of heat or electricity. But admitting a whirlwind to be produced, not by a deficit of pressure about the axis, but by unequal and opposing forces acting externally, in any competent way whatever, is it not evident that any deficit of pressure about the axis, consequent to the resulting centrifugal force, could only cause in the atmosphere a descending current, while it could not tend in the slightest degree to carry solids or liquids aloft? It must be obvious, that the stratum of air on the earth's surface, partaking of the circular motion, must also partake of the centrifugal momentum, and of course would have the inverse of any disposition to rush towards the axis so as to be productive of a vertical blast. Meanwhile the air being rendered rarer by the centrifugal momentum imparted as above alleged, ponderable bodies envel-

oped by it would have their gravity less counteracted than usual, and consequently far from acquiring any tendency to rise, would be unusually difficult to elevate.

28. I cannot help thinking that as respects the application of his "rotary theory" to account for the upward movement which appears to be essential to tornadoes, these arguments will amount to a "*reductio ad absurdum*."

29. Mr. Redfield infers that the whirlwinds of which he assumes the existence, have a property which he alleges to be observable in "all narrow and violent vortices," viz. "a spiral involute motion quickened in its gyrations, as it approaches towards the centre of the axis or whirl."^{*} But is it not evident, that if any fluid mass be made to revolve by unequal and opposing forces, or by any other than those resulting from the centripetal force, caused, as already described, by suction at the axis, the gyration will not quicken, in proportion as the gyrating matter may be nearer the centre; but on the contrary, will be slower as the distance from the axis may be less? It appears to me that the only case in which gyration is found to quicken in proportion as the matter involved approaches the vortex, is that which results from a confluence caused by an ascending or descending current at the axis of the whirl.

30. So far therefore as Mr. Redfield's observations confirm the idea that the whirling motion in tornadoes quickens towards the centre, it tends to confirm the opinions which he combats, and to refute those which he upholds.

31. Although the efforts which I have made to show that the phenomena of tornadoes and hurricanes arise from electrical reaction should not be successful, I think it will be conceded that any theory of storms which overlooks the part performed by electricity must be extremely defective.

32. Both by Messrs. Espy and Redfield the influence of this agent in meteorological phenomena is entirely disregarded, although with the storms which have been especially the subject of their lucubrations, thunder and lightning and convective discharge are most strikingly associated.

* See this Journal, Vol. xxxi, p. 130.

